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BUTTERFLY DAMPER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a butterfly damper for a loudspeaker, and especially to a high-input type butterfly damper.

Description of the Related Art

The conventional butterfly damper 7 has an inner circumferential frame 9, an outer circumferential frame 8 and arm members 10 for connecting the inner circumferential frame 9 and the outer circumferential frame 8 to each other, as shown in FIG. 5. A voice coil is inserted into the inner circumferential frame 9. The outer circumferential frame 8 is fixed to the other structural component (for example, a framework of the loudspeaker). Excitation of the voice coil causes the inner circumferential frame 9, which is supported by means of the arm members 10 having flexibility, to vibrate together with the voice coil.

The conventional butterfly damper 7 is formed utilizing the injection forming so that the arm member 10 and the outer circumferential frame 8 are connected to each other to form a flush surface, taking into consideration simplification of the parts and facilitation of the injection forming. More specifically, the arm member 10 and the outer circumferential frame 8 are connected to each other so that the upper surface 8a of the outer circumferential frame 8 is flush with the upper surface 10a of the arm member 10, as shown in FIG. 6.

The conventional butterfly damper 7 however has a problem that amplitude increased by inputting a high input signal causes stress concentration in the arm member 10, resulting in a state in which the arm member 10 is not able to bear the stress, leading to its breakage or

occurrence of rupture. The conventional butterfly damper 7 is not adaptable to the high input signal in this manner.

Stress tends to concentrate on the connecting portion of the arm member 10 to the outer circumferential frame 8, and more specifically on the portion of the connecting portion, which has a small curved surface.

SUMMARY OF THE INVENTION

An object of the present invention is therefore to provide a butterfly damper, which has a shape feature by which stress can be distributed and reduced, thus permitting to bear a high input signal.

In order to attain the aforementioned object, a butterfly damper according to the first aspect of the present invention comprises:

an inner circumferential frame;

an outer circumferential frame having opposite end surfaces and an inner peripheral surface, said inner peripheral surface being connected to said opposite end surfaces to form opposite connecting edge portions; and

at least one arm member having one end connected to said outer circumferential frame and an other end connected to said inner circumferential frame,

wherein:

said one end of said at least one arm member is connected to a portion of said inner peripheral surface of said outer circumferential frame, said portion excluding said opposite connecting edge portions.

According to the first aspect of the present invention, the one end of the at least one arm member is connected to a portion of the inner peripheral surface of the outer circumferential frame, which excludes the opposite connecting edge portions. Even when operation of the damper

causes the inner circumferential frame to oscillate, the above-mentioned portion of the inner peripheral surface of the outer circumferential frame serves as a blocking wall for preventing the arm member from oscillating excessively, thus reducing stress.

In the second aspect of the present invention, each of the one end and the other end of the at least one arm member may have at least one curved surface. According to the second aspect of the present invention, the curved surface is formed at each of the opposite ends of the arm member, which connects the inner circumferential frame and the outer circumferential frame to each other, in the vicinity of which stress concentration tends to occur. It is therefore possible to distribute stress, which is to be applied to the adjacent portion of the arm member as connected, to the end thereof, thus reducing the load of stress.

In the third aspect of the present invention, a plurality of arm members may be provided as the at least one arm member. According to the third aspect of the present invention, it is possible to make a change in length, width and the other conditions of the arm member to the optimum values in accordance with a level of an input signal value and a size of the butterfly damper. Selection of the appropriate values for these conditions may lead to variation in the number of the arm members. There is no limitation in the number of the arm members.

In the fourth aspect of the present invention, the inner circumferential frame, the outer circumferential frame and the at least one arm member may be formed of resin integrally with each other by an injection forming. According to the forth aspect of the present invention, utilizing the injection forming makes it possible to manufacture the integrally-formed butterfly damper in an easy manner. In the present invention, change in shape of the damper suffices to improve only performance of it without increasing a cost.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view illustrating the whole structure of a butterfly damper of the present invention;

FIG. 2 is a cross-sectional view cut along the line II-II in FIG. 1;

FIG. 3 is an enlarged view illustrating the connecting portion of an arm member and an outer circumferential frame of the butterfly damper of the present invention;

FIG. 4 is a partial perspective view illustrating the butterfly damper of the present invention;

FIG. 5 is a plan view illustrating the conventional butterfly damper; and

FIG. 6 is a cross-sectional view cut along the line VI-VI in FIG. 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, an embodiment of a butterfly damper of the present invention will be described in detail below with reference to the accompanying drawings. FIG. 1 is a view illustrating the whole structure of a butterfly damper of the present invention, FIG. 2 is a cross-sectional view cut along the line II-II in FIG. 1, FIG. 3 is an enlarged view illustrating the connecting portion of an arm member and an outer circumferential frame of the butterfly damper of the present invention, and FIG. 4 is a partial perspective view illustrating the butterfly damper of the present invention.

The butterfly damper 1 has an outer circumferential frame 2 having a ring-shape, an inner circumferential frame 3 and arm members 4, 4, 4 and 4. The inner circumferential frame 3 is disposed in the inside of the outer circumferential frame 2 and has a ring-shape. The arm members 4, 4, 4 and 4 are provided between the outer

circumferential frame 2 and the inner circumferential frame 3.

The outer circumferential frame 2 has the outer peripheral surface 2a, the inner peripheral surface 2c and the opposite end surfaces. The inner peripheral surface 2c is connected to the opposite end surfaces to form the opposite connecting edge portions. The outer circumferential frame 2 is provided on the outer peripheral surface 2a with an engaging portion 2b having a recess into which the other structural component (for example, a framework of a loudspeaker) is to be fitted. One end of each of the arm members 4, 4, 4 and 4 is connected to the inner peripheral surface 2c of the outer circumferential frame 2 so that the arm members 4, 4, 4 and 4 are placed at prescribed intervals. The engaging portion 2b may not have the above-mentioned recess.

Each of the arm members 4, 4, 4 and 4 has an arm-main body 4a, which is formed into an S-shape so as to be placed between the outer circumferential frame 2 and the inner circumferential frame 3. The arm-main body 4a has an elastic deformation property so that the outer and inner circumferential frames 2 and 3 are elastically connected to each other. The arm-main body 4a has a central portion that is disposed between the outer and inner circumferential frames 2 and 3 so as to be substantially in parallel with them, and the opposite edges that have a bent-shape by which the opposite edges intersect the outer and inner circumferential frames 2 and 3 substantially at right angles and are connected thereto, respectively. Each of the opposite edges of the arm-main body 4a, which have the above-mentioned bent-shape, is provided with a projection 4b for enhancing strength of the arm-main body 4a. The one end of the arm member 4a is connected to the inner peripheral surface 2c of the outer circumferential frame 2 and the other end thereof is connected to the outer peripheral surface 3c of the inner

circumferential frame 3. Each of the one end and the other end of each of the arm members 4, 4, 4 and 4 has curved surfaces in the vicinity of the connecting portion to the outer or inner circumferential frame 2 or 3. The four arm members 4, 4, 4 and 4, which are disposed between the inner circumferential frame 3 and the outer circumferential frame 2 at the prescribed intervals, are symmetrical of rotation.

The other end of each of the arm members 4, 4, 4 and 4 is connected to the outer peripheral surface 3c of the inner circumferential frame 3 so that the arm members 4, 4, 4 and 4 are placed at prescribed intervals. The inner circumferential frame 3 is provided on its inner peripheral surface 3b with a plurality of projections 3a ...3a, which are placed at the prescribed intervals so as to extend toward the center of the inner circumferential frame 3. These projections 3a ... 3a define a hole 5, which substantially coincides with the outside diameter of the voice coil, so that the voice coil can be fitted into the hole 5. Accordingly, the voice coil is supported on its outer peripheral surface by the above-mentioned projections 3a ... 3a.

As shown in FIGS. 1 to 4, the one end of each of the arm members 4, 4, 4 and 4 is connected to a portion of the inner peripheral surface 2c of the outer circumferential frame 2, which portion excludes the above-mentioned opposite connecting edge portions of the outer circumferential frame 2. More specifically, the one end of the arm member 4 exists on the intermediate portion of the inner peripheral surface 2c, excluding the opposite connecting edge portions, in the operating direction (i.e., the vertical direction in FIGS. 2 and 3) of the damper 1. In other words, the upper surface of the one end of the arm member 4 is lower than the upper end surface of the outer circumferential frame 2 and the lower surface of the former is higher than the lower end surface of the latter, in the vertical direction in FIG. 3,

so that the outer circumferential frame 2 projects upward from and downward below the above-mentioned one end of the arm member 1 in FIG. 2.

The inner circumferential frame 3, the outer circumferential frame 2 and the arm members 4, 4, 4 and 4 are formed of resin integrally with each other by the injection forming. Polypropylene or polybutylene terephthalate (PBT) is suitably used as the above-mentioned resin. A reason for application of the injection forming is that the thickness of the damper can appropriately be set by changing a mold(s) and the thickness thereof can also be increase or decreased partially, thus coping easily with change in design of the damper, in comparison with the conventional damper, which is formed by a punching method and has a limitation of thickness thereof due to the thickness of a blank sheet material, leading to difficulty in formation of the desired shape.

When strength required for the inner circumferential frame 3 and that required for the outer circumferential frame 2 are compared, the outer circumferential frame 2 requires a larger strength than the inner circumferential frame 3 in view of the fact that the outer circumferential frame 2 must bear oscillation caused by excitation of the voice coil, which is inserted into the inner circumferential frame 3. In addition, the inner circumferential frame 3, which is influenced by oscillation of the voice coil, requires flexibility. Accordingly, the outer circumferential frame 2 is preferably formed into a shape having the large cross-sectional area and the large thickness. On the contrary, the inner circumferential frame 3 is preferably formed into a shape having the smaller cross-sectional area and the smaller thickness than those of the outer circumferential frame 2.

Now, operation of the butterfly damper of the present invention will be described below.

The butterfly damper 1, which is composed of the outer circumferential frame 2, the inner circumferential frame 3 and the arm members 4, 4, 4 and 4 connecting the outer circumferential frame 2 and the inner circumferential frame 3 to each other, is fitted into the other structural component (for example, the framework of the loudspeaker) and fixed thereto so that the engaging portion 2b formed on the outer peripheral surface 2a of the outer circumferential frame 2 receives the other structural component. The voice coil is inserted into the hole 5 of the inner circumferential frame 3. The voice coil is supported resiliently by means of the projections 3a ... 3a provided on the inner peripheral surface 3b of the inner circumferential frame 3 in this manner.

Excitation of the voice coil causes its oscillation in the operating direction (i.e., the vertical direction in FIG. 2) of the voice coil so that the inner circumferential frame 3 also reciprocates in synchronization with the above-mentioned oscillation of the voice coil. During a reciprocating motion of the inner circumferential frame 3, the arm members 4, 4, 4 and 4 connected to the outer peripheral surface 3c of the inner circumferential frame 3 is elastically deformed in synchronization with the reciprocating motion. Oscillation caused by the voice coil, which is supported by the inner circumferential frame 3, is absorbed by elastic deformation of the arm members 4, 4, 4 and 4 connected to the inner circumferential frame 3 during the excitation of the voice coil, while the outer circumferential frame 2 is stationarily supported.

Oscillation caused by the voice coil becomes larger, according as a value input into the voice coil becomes higher. Amplitude of the inner circumferential frame 3 also increases accordingly. In the conventional butterfly damper, increased amplitude of the inner circumferential frame 3 causes stress concentration on the connecting portions of the arm members 4, 4, 4 and 4 to the inner circumferential frame 3 and the outer

circumferential frame 2, leading to a possible occurrence of breakage (or rupture) of the connecting portions.

In the embodiment of the present invention, the one end of the arm member 4 exists on the intermediate portion of the inner peripheral surface 2c, excluding the opposite connecting edge portions, in the operating direction (i.e., the vertical direction in FIGS. 2 and 3) of the damper 1, in order to prevent the amplitude of the arm member 4 from increasing during excitation of the voice coil. Connecting the one end of the arm member 4 to the outer circumferential frame 2 in this manner makes it possible to restrict the movement of the arm member 4, which is caused by oscillation of the inner circumferential frame 3, through the outer circumferential frame 2. Thus, the amplitude of the arm member 4 can be decreased and consequently the amplitude of the inner circumferential frame 3 can also be decreased, thus reducing stress.

In the embodiment of the present invention, each of the one end and the other end of each of the arm members 4, 4, 4 and 4 has the curved surfaces in the vicinity of the connecting portion to the outer or inner circumferential frame 2 or 3. Formation of such curved surfaces makes it possible to distribute stress, thus preventing occurrence of fissures or cracks.

Stress was measured in a state in which the outer circumferential frame was stationarily supported and a prescribed load was applied to the inner circumferential frame, for each of the conventional butterfly damper and the butterfly damper of the present invention. Measurement results are shown in Table 1 below. Difference between the conventional butterfly damper and the butterfly damper of the present invention exists in that, as is clear from FIGS. 3 and 6, the connecting portion of the arm member to the outer circumferential frame of the conventional butterfly damper is formed into

an L-shape in its cross section, and on the contrary, the connecting portion thereof of the butterfly damper of the present invention is formed into a T-shape in its cross section.

TABLE 1

Kind of damper	Maximum stress (N/cm^2)	Maximum displacement (mm)	Variation (%)
Conventional	$4.41 \cdot 10^7$	3.61	100
Present invention	$4.24 \cdot 10^7$	3.32	96

Measurement, results of which are shown in TABLE 1, was made, while applying load of 9 (N) to the inner circumferential frame. Polybutylene terephthalate (PBT) resin was used as material for forming the butterfly damper. As shown in FIG. 1, the maximum stress in the conventional butterfly damper was $4.41 \cdot 10^7$ (N/cm^2). On the contrary, the maximum stress in the butterfly damper of the present invention was $4.24 \cdot 10^7$ (N/cm^2). It is recognized from the results that stress was reduced by about 4 %.

Regions 6 and 6 in FIG. 4 denote portions in which stress concentration tends to occur. As shown in FIG. 4, stress concentration tends to occur in portions having the smaller curved surfaces in the vicinity of the connecting portions of the arm member 4 to the outer and inner circumferential frames 2 and 3, respectively. Also in the conventional butterfly damper, stress concentration tends to occur in portions in the vicinity of the connecting portions of the arm member to the outer and inner circumferential frames, respectively.

When load is applied in this manner, stress such as bending stress, which is to be applied to the arm member, tends to concentrate in an extended portion of the arm member (i.e., a connecting portion of the arm member, which is connected to the outer circumferential frame, in this case). In the butterfly damper of the present invention, the arm

member 6 is provided, in the vicinity of the connecting portion, with the small curved surface, to which the maximum stress is applied. In the conventional butterfly damper, the arm member 10 is smoothly connected to the outer circumferential frame 8 so that the upper surface of the arm member 10 is flush with the upper surface of the outer circumferential frame 8. It is therefore presumed that force caused by the oscillation motion is transferred to the outer circumferential frame 8 so as to lift up slightly the outer circumferential frame 8, thus leading to an increased amplitude (displacement) and an increase stress. On the contrary, in the butterfly damper of the present invention, the one end of the arm member 4 is connected to the portion of the inner peripheral surface 2c of the outer circumferential frame 2, which portion excludes the opposite connecting edge portions of the outer circumferential frame 2. More specifically, the one end of the arm member 4 exists on the intermediate portion of the inner peripheral surface 2c, excluding the opposite connecting edge portions, in the operating direction of the damper 1. It is therefore presumed that the amplitude can be decreased, thus reducing stress.

The present invention, which is not limited only to the above-described embodiment, can be carried out in the other embodiments. The number of arm members may be varied in an appropriate manner.

According to the present invention as described in detail, it is possible to provide the butterfly damper, which has a shape by which stress can be distributed and decreased in the portion in which stress tends to concentrate. Change in shape of the butterfly damper provides the technical effects of bearing a high input signal, without increasing a cost.

The entire disclosure of Japanese Patent Application No.

2001-55073 filed on February 28, 2001 including the specification, claims, drawings and summary is incorporated herein by reference in its entirety.